CHAPTER 4

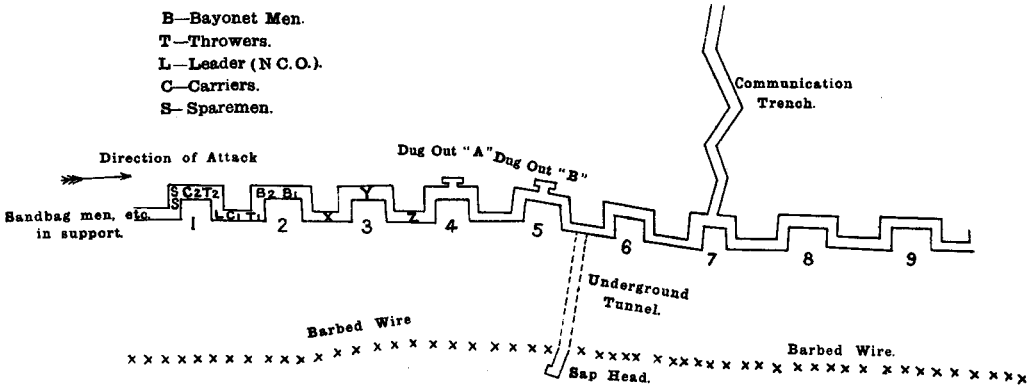
Mills and Patent Hand Grenades 1915–16

From August 1914 to November 1918, more than a hundred patents were granted in respect of inventions related to hand grenades, thirty-nine of which were applied for in 1915 alone. Most of these were concerned with the fuse and firing and safety mechanisms as these were the fundamental parts of the bomb and determined not only how it worked but whether it would work at all. By far the majority sank without trace. Some were merely misguided attempts to come up with something that could solve the problems at the Front. Others were speculative forays into the field of military engineering and munitions in the hope that the government would place contracts for the grenade. Mostly, this was a forlorn hope and it did not happen because the Munitions Inventions Department or the Trench Warfare Department or some other department or committee, charged with sifting the potentially serviceable from the outright useless, did not regard it to be an improvement over what already existed. Mostly, they were right.

Many were simply unworkable or had some flaw unforeseen by the inventor. The granting of a patent did not mean that the invention actually worked. Even when something was adopted for trials, or events had progressed well beyond the trial stage, it was all too common for unexpected faults to show themselves as soon as the grenades came into contact with soldiers at the Front, who were apt to do things unimagined or overlooked by the inventor or anyone investigating its usefulness as a weapon of war. This was certainly true of the early Mills grenades. Sometimes the invention got to the trials stage but no further and, on occasions, a great deal of time and money were expended trying make a grenade work or in rectifying defects that caused accidents.

It was a rather complicated situation and a direct result of the sudden need for grenades when there were none. The design and supply of grenades tended to occur simultaneously because of the urgency. Inevitably, this meant that there was 'no time available for exhaustive experiments with a view to producing a perfected article'. Every new pattern of grenade that found its way to the Front in 1915 was flawed, including the Mills. Moreover, once the administrative machinery for meeting the demands had been put into operation for a particular pattern, from the placing of contracts to getting the grenades to the men at the Front, it was no simple matter to call a halt and start all over again with a different pattern. There were delays and dislocations with unavoidable shortages. This became a serious problem so there was no incentive whatsoever to take on a design of grenade which might, in time, turn out to be safe and effective. It had to be workable right from the start and offer tremendous advantages over what was already in service or in the pipeline. Consequently, it is not surprising that trench warfare departments tended to be lukewarm about new inventions brought to them by hopeful inventors. For many inventors the patenting of grenade inventions was a waste of time and effort.

It was further complicated by the necessity of training, something that was often overlooked by inventors. Under Major Claude Beddoes of the Gloucestershires, the first



A diagram from The Training and Employment of Grenadiers *showing how to clear enemy trenches using grenades, as taught in late 1915. It was acknowledged that there was unlikely to be enough room in a trench for two bombers to stand side by side to throw their grenades. X, Y and Z are the bombers' targets from the positions shown. When the bayonet men report that the bombed areas are clear of enemy the whole party advances, the bayonet men taking up positions in traverse 3.*

school to train bombing instructors was set up at Clapham, south London, in the spring of 1915. In time, a bombing school was established in each Home Command and Major Beddoes was appointed as Inspector of Bombing Schools, GHQ Home Forces in January 1916. He became the Experimental Officer for Trench Stores to the Ministry of Munitions and during 1916 liaised with the Army in France. These schools made a considerable contribution to the reduction of accidents by providing proper training in the handling and use of grenades, each pattern of which required different procedures. Whenever a new pattern of grenade was adopted by the Army, new training programmes had to be instituted. It was a constant battle during 1915 to keep up when so many different patterns were being supplied to the Army. Once scientific training methods were introduced, standards rose and fatal accidents during training decreased to 10 in 74,000, the number of officer and NCO bombing instructors who successfully passed through the Home Training Schools. Discipline was, of course, a major factor and in these schools it was rigid. According to Lieutenant-Colonel Brothers after the war, 11,863,012 Mills grenades were fired from rifles or thrown during training at the schools.

Brothers explained that because of the grenade problem 'It became necessary . . . to balance the advantages offered by an improved Grenade, against the supply and training problem involved by its introduction to the Service'. None of this helped prospective inventors who believed that they had an even chance, at least, of getting a fair hearing. Although patenting their inventions was, perhaps, a logical thing to do to protect their interests, in the most part it was to no purpose because no one was going to make their grenades.

The curious thing about all these patents is that they were published during what was a time of war, as publication meant that anyone 'skilled in the art' could make use of the information either to manufacture grenades, provided they had the facilities, or to gain valuable information about how they worked. And that included the enemy. A patent has to

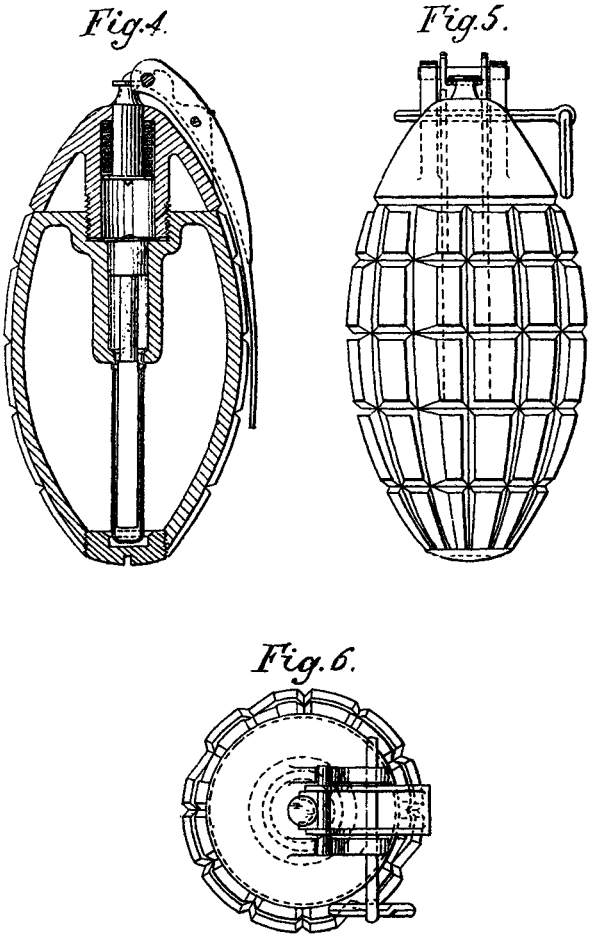
contain sufficient information for a person to make the article, perform the process or carry out whatever the invention claimed to be. Patents could be made secret under the provisions of the 1907 Patents Act, however, and indeed at least one secret application was filed and granted as a patent. This was the application filed by Sir Ernest Moir, head of the Munitions Inventions Department; the subsequent patent was not published (secret patent No. 88). Simply because the patents were published in Great Britain, rather than worldwide, would not have precluded sight of them by unwanted eyes – those of the enemy.

This would only have mattered, of course, provided the invention was not only workable but practical. There is no evidence to suggest that the Germans did make use of the information in any UK patent to produce weapons although they may have gained useful information by studying them. Strangely, no one in Britain seems to have considered looking at German patents or British patents granted to German companies before the outbreak of war. (A case in point is flamethrowers. There was at least one British patent owned by a German company dating from 1910 but no one seems to have looked at it when the British were trying to develop flamethrowers in response to their use by the Germans in 1915.)

The alternative to a secret patent, of course, was to publish nothing about it at all. That way, the invention remained secret. To a large degree, the question of secrecy would only have arisen for patent applications related to inventions made by those in the military or a member of one of the government departments or committees concerned with the development of new weapons. There were certainly rules governing the patenting of inventions made by such people during the war but it was grey area. A civilian would not have been subject to the same rules. Nor is it likely that he would have been aware of the secrecy provisions in the Act. Neither would he have considered the advisability or otherwise of having his invention published in a form that could aid the enemy since most applicants were interested solely in protecting their property from unlicensed use. An invention is, after all, property and a patented one is afforded legal protection. On the other hand, an invention that remains secret is also protected simply because it is not known. Moreover, it was not necessarily the job of the patent examiners in the Patent Office to decide whether something should become a secret application although they might draw a likely candidate to the attention of the War Office. However, there is nothing to suggest that this ever occurred.

Nevertheless, it did worry some people – Captain James Leeming of the Trench Warfare Department for one. He was concerned that the publication of a grenade patent abridgement in the 22 December 1916 edition of the *Engineer* would provide useful information to the enemy (although it begs the question of why he was unaware of the patent until its appearance in the journal since it was only reproducing what had already been published by the Patent Office). A note written by Louis Jackson on 17 January 1917 stated, in a somewhat convoluted way, that 'we do not stop patents that are not likely to be taken up by ourselves or to be useful to the enemy'. By implication, this indicated that the Trench Warfare Supply Department, or indeed any other similar department or committee, would stop a patent that was going to be taken up by the British government or one that was potentially useful to the enemy. If an invention was passed (i.e. accepted) by the Trench Warfare Supply Department, publication of any patent related to it would have been considered likely to provide useful information, though there is no evidence to suggest that they ever stopped one. Indeed, the contrary seems to be the case as there are several instances of patented inventions being taken up, the most significant of which are the Mills grenade and Stokes mortar patents.

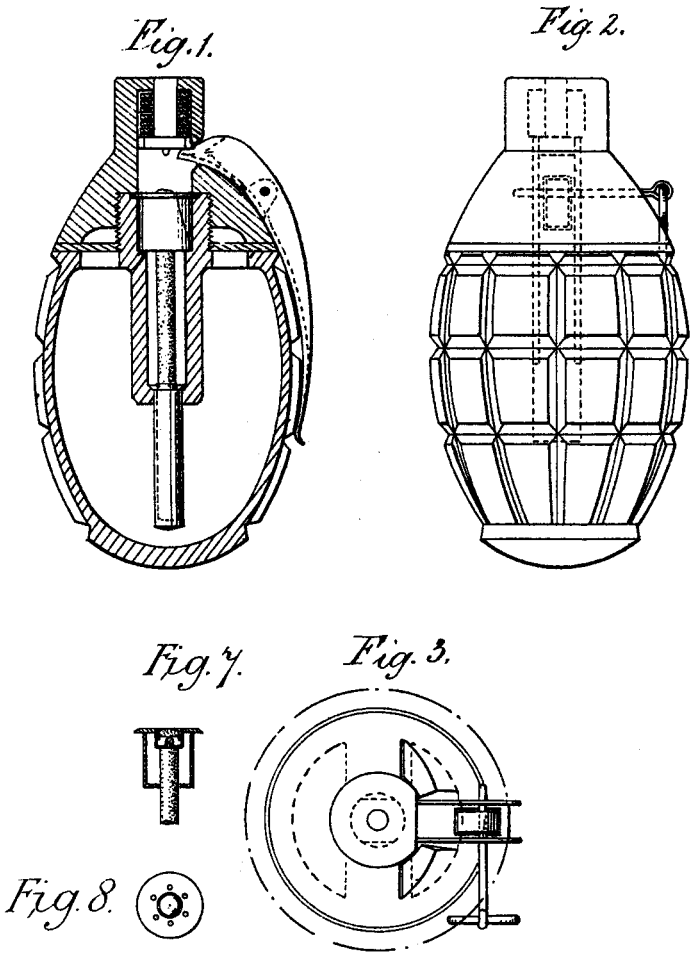
In any event, it appears that Leeming's concerns were misplaced. The patent in question was H.D. Black's grenade patent, 15,984/15, a feature of which was a safety device to prevent premature detonation if the grenade was accidentally dropped. The application had



The time-fused grenade invented by Captain Leeming, Frank Brewerton and Frederick Fraser (UK patent 11,679/15). The head containing the firing mechanism is screwed into the body immediately prior to use. It has a lever mechanism similar to the Mills.

been filed on 12 November 1915. Black was one of three co-patentees, Frank Brewerton and Frederick Fraser being the other two. The grenade had been submitted to the Trench Warfare Department and Leeming was of the opinion that it was one of the best devices the department had seen and therefore the patent should not have been published. However, Louis Jackson, the Director General of Trench Warfare Supply, disagreed, pointing out that it was impractical and had been rejected. Needless to say, Black's grenade was not taken up.

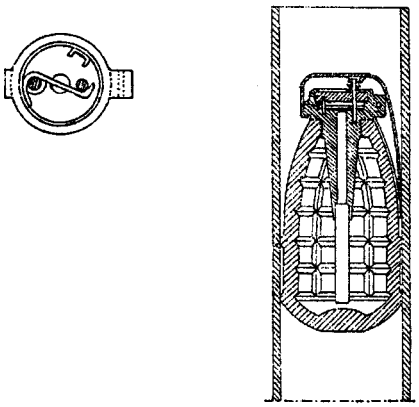
There was, however, another side to this. Leeming, Brewerton and Fraser had been co-patentees on an earlier application for a grenade patent, subsequently granted as UK patent 11,679/15. This had been accepted by the Patent Office and published before publication of the offending abridgement in the *Engineer*. The later patent which named Black was a development of the earlier invention which was concerned with what was, in effect, a two-part device. One part constituted the body with explosive, detonator and fuse, the other 'head



Another version of the Leeming grenade with a different sort of firing mechanism. The lever holds the bottom of the striker instead of the top.

part' containing the firing mechanism locked by a safety device in the 'inoperative position until the grenade is to be used'. The idea was to screw in the head immediately prior to use. The invention was a clever idea but it was not taken up. Passing over the fact that the earlier patent was published with Leeming's full knowledge, Leeming may have been under the impression that the Black grenade, and by association his own, had been accepted by the Trench Warfare Department. Maybe he was upset by the failure to get his own accepted.

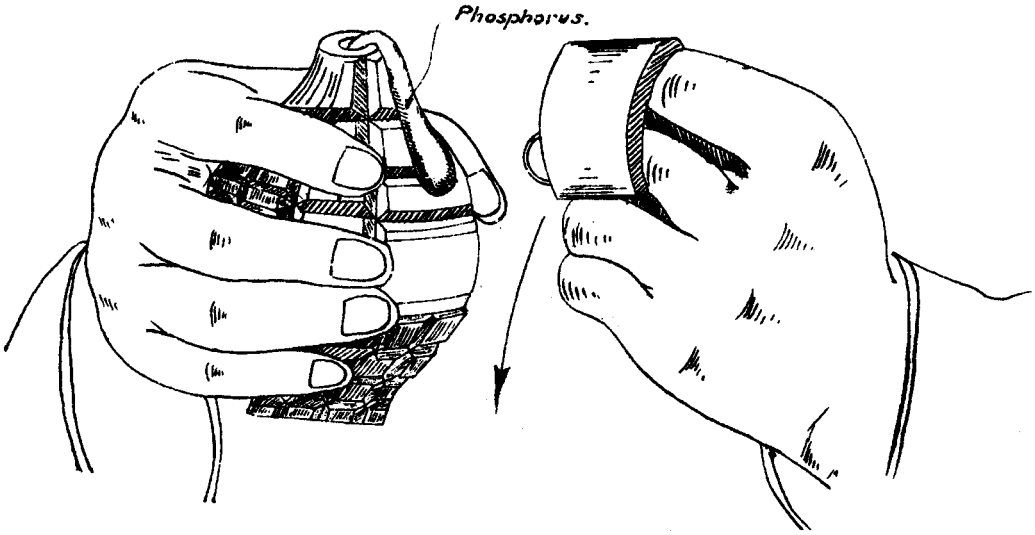
Not all of the patents relate to British grenades, of course: some are French or Belgian inventions. Some of these were adopted by the French or Belgian armies. UK patent 11,551/15 granted to L.L. Billant (who filed several other applications for grenade patents during the war) was a percussion-fused hand grenade adopted by the French as Grenade P1. In September 1915 General Maxwell told the War Office that the BEF was considering the French P Modele 1915 made by a Paris firm because of the shortage of grenades being



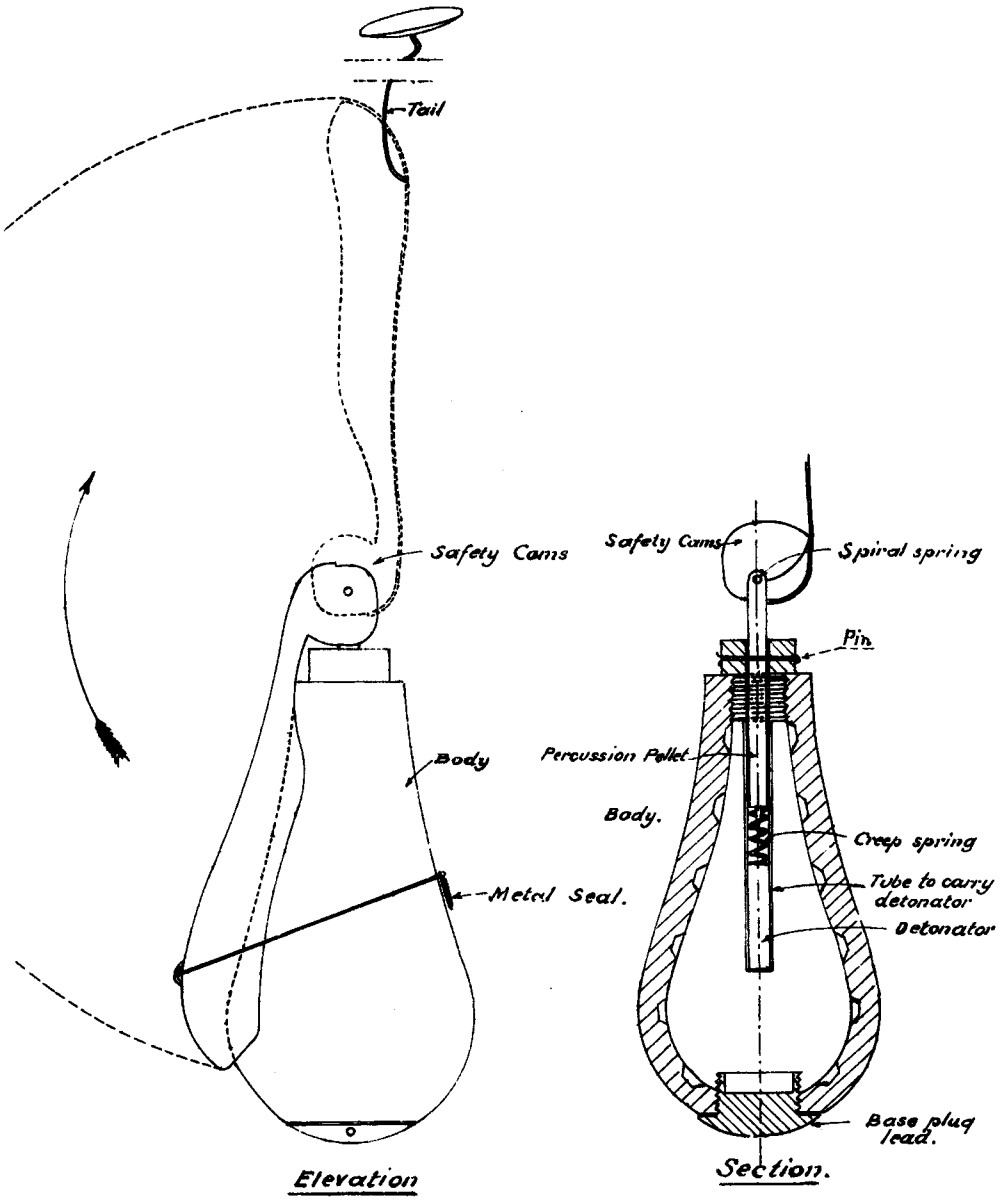
Drawings from L.L. Billant's patent, 127,279. In the plan view on the left, the striker is the flat spring going from left to right. The retaining pin (it is on the right at the top of the grenade in the left-hand figure) is held in place by another spring which is retained by the lever. The striker pivots about the short pin on the left (right-hand figure). The grenade is shown in a discharge tube but how to insert it so far down is not explained.

supplied to the BEF. It was probably the Billant grenade. In the end, considering did not turn into adopting and the grenade did not see British service. Then there was 11,747/15, filed at the UK Patent Office on 10 March 1915, which became the French Besozzi grenade, named after its inventor. This had a friction igniter similar to the matchhead types in British service at the time, the matchhead being protected from the wet by a brass cap. There were others.

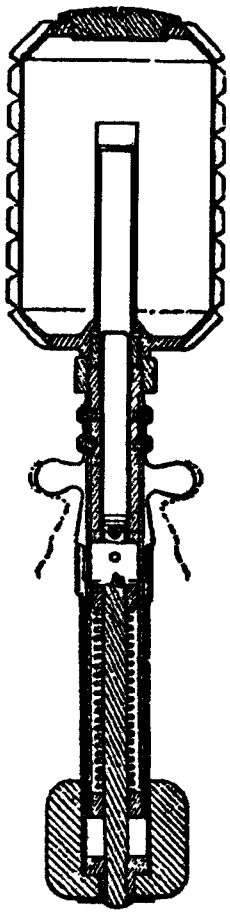
Since the first hand grenades used by the British Army were stick grenades it is not surprising that, at first, inventors should follow this line of development and try to overcome the inherent hazard of percussion grenades. On 10 February 1915 the firm of W.M. Still & Sons filed an application for a stick grenade with the firing pin in the handle, activated by the act of throwing. It used a time fuse rather than an impact one although there was provision for an impact fuse when the grenade was adapted to be a rifle grenade. The mechanism was neither robust nor simple enough for field use and it is likely that manufacture would have been too



The Besozzi grenade and how to ignite it, as illustrated in The Training and Employment of Grenadiers *of October 1915. The fuse is about 2 in long and bent over and waxed to the body of the grenade and tipped with red phosphorus. The grenades came with the necessary accompaniment, a striker box or ring. It was essential that the phosphorus tip was struck with a downward motion of the striker box to prevent the fuse being pulled away and consequently failing to ignite.*



The French Pear percussion grenade of 1915. This may have been the P Modele 1915 (although, confusingly, Billant's grenade was called the P1). It was 3.5 in long with a maximum diameter of 2 in and contained 1 oz of explosive. The aluminium lever was secured to the body with a string fastened with a metal seal. An 18 in streamer or tail with a small metal 'steadying plate' was attached to the lever and folded beneath it. The cams on the top of lever held the striker until the grenade was thrown. When the lever flew up, the cams were freed from the grenade neck, freeing the striker. Like the Mills, the grenade was held with the lever against the palm and immediately before throwing the seal was twisted off. (The Training and Employment of Grenadiers)



The side projections are leaf springs which hold the firing pin until the grenade is thrown. The dotted lines show the springs after being released by inertia of the central shank. Still's patent 2,139/15.

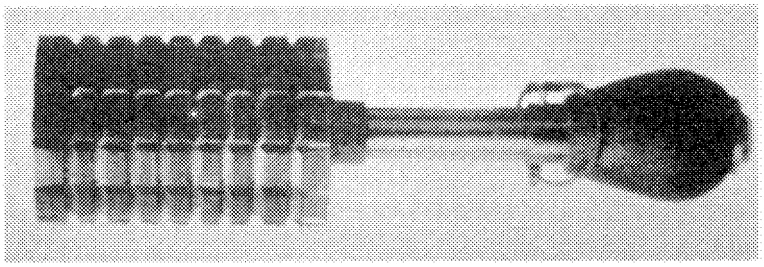
complex for quick production. It was not adopted. A few days after Still & Sons filed their application, Frederick Marten Hale filed an application for a similar device, a development of his patented grenade (4,925/11) of 1911. This was another complex design that would have been far too complicated for quick production. Moreover, it was a prime candidate for accidental detonation due to rough handling because of the way the striker was released, achieved by the act of throwing.

Arthur Cardwell Roodhouse took a different approach. He was an 'explosives merchant' who lived in Wigan and he invented a hand grenade of two concentric spheres and a firing mechanism. His application, filed on 20 March 1915, became UK patent 4,392/15. His complete specification stated:

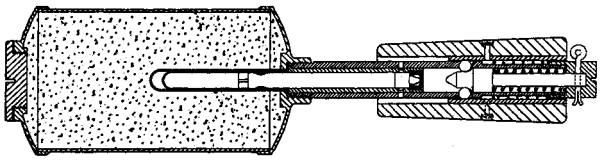
> Heretofore it has been proposed to make spherical bombs of solid, thick, metal, with zonal grooves at intervals so that part of the force of the explosion shall be exerted in breaking the bomb into rings corresponding to these zonal grooves. It has also been proposed to make cylindrical bombs formed of two casings with hemispherical ends, the inner casing containing picric acid, and the space between the cylindrical as well as the hemispherical parts of the two casings being filled with steel balls.

His invention was intended to take 'all the advantages obtained from both' and provide a grenade with additional 'advantages not found in either'. This suggests that Roodhouse was aware of the current developments in service grenades, the Lemon and the Jam-Tin in particular, when he invented his but that was not the case. Moreover, his understanding (or perhaps that of his patent agent) of fragmentation was clearly not based on sound knowledge. He believed that because the grenade was spherical, blast would inevitably be radial and equal in all directions. It is highly improbable this would have happened in practice.

The grenade consisted of an outer sphere made from two hemispheres of 'Swedish tinned sheet iron . . . soldered, brazed, welded' together to form an airtight container. Inside this and attached to it was a second similar sphere. Roodhouse was aware of the problems caused by damp and made it clear that all the openings in the outer sphere – such as for the explosive filling tube and for the detonator and firing mechanism – were covered by airtight and watertight closures. The inner sphere contained the explosive and the space between them



Hale's patent safety grenade (UK patent 3,091/15), photographed in the summer of 1915. Hale claimed it would produce 200 fragments. Compare this with the patent drawing below. (ILN)



Hale's hand grenade in which the firing pin is released by inertia during the act of throwing after the pin has been removed.

was filled with shrapnel. The firing mechanism was a neat device, resembling that used in the Mills, using a striker to hit a percussion cap which ignited the time fuse which in turn ignited the detonator. It had a trigger and a safety catch of wire to prevent the trigger activating the striker until the bomber was ready to throw it.

All in all, this was a neat and potentially safe and effective grenade. It sufficiently impressed one of the trench warfare departments that it went into limited production so that trials could be conducted. Unfortunately for Roodhouse it did not pass and was rejected, most likely because the Mills was superior, although the safety may have presented problems as it had the potential to be accidentally moved off the trigger without its unlucky user noticing.

Although the time fuse quickly supplanted the percussion fuse for hand grenades, inventors endeavoured to overcome the inherent problems and develop a safe 'all-ways' fuse that would detonate the grenade irrespective of the angle of impact. James Frank Buckingham developed several fuses of this type. UK patent 4,407/15 described a mechanism that used a vibrator with an eccentric weight on the vibrator stem, while 5,553/15 described a development of this in which the vibrator was located in a grenade at a position distant from the grenade's centre of gravity and at an angle to it. Buckingham was the owner of an engineering company in Coventry and was already working on incendiary bullets. The Buckingham incendiary was

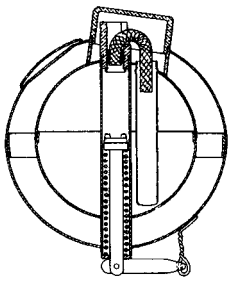


Fig. 1.

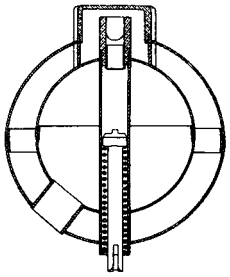
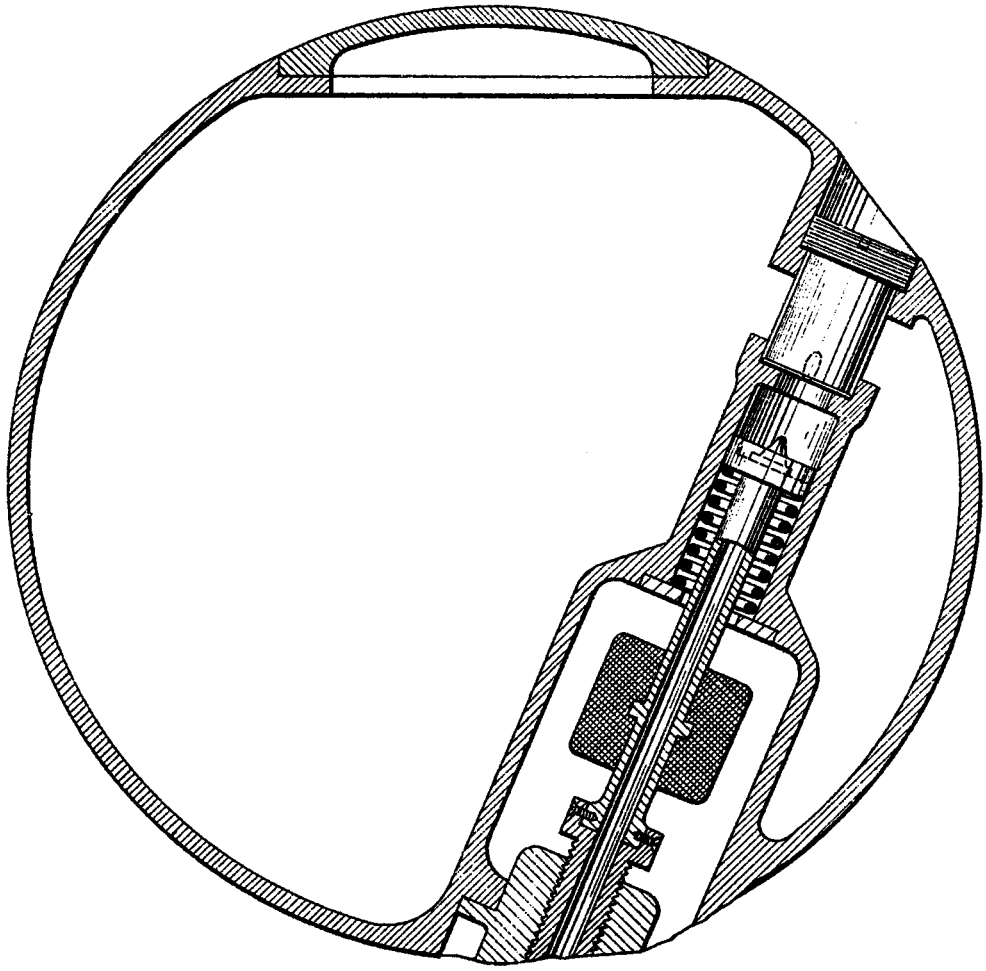


Fig. 2.

Arthur Roodhouse's hand grenade (UK patent 4,392/15). In fig. 2, the grenade is turned through 90° to fig. 1. From these drawings, the flimsiness of the safety device is readily apparent.



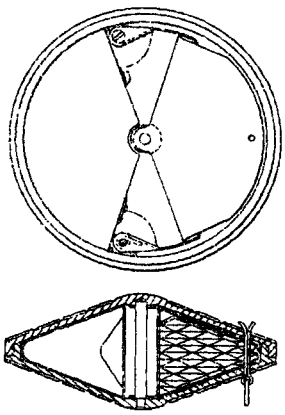
James Buckingham's percussion ball grenade (UK patent 5,553/15). The narrow stem leading back from the firing pin is broken on impact by the weight in the chamber, thereby freeing the firing pin to strike the detonator.

subsequently used by the Royal Naval Air Service and the Royal Flying Corps. However, his impact fuses did not find favour.

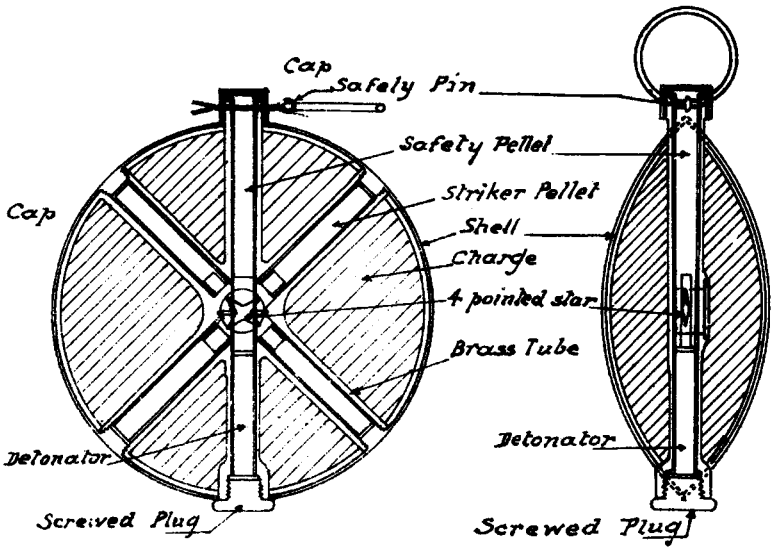
One of the oddest grenade inventions was J.A. Armstrong's. He filed an application on 8 September 1915 for a wheel-shaped grenade which, although it could be thrown, was intended to be rolled along the ground at the enemy. Just how this was to be done in the trenches and under fire was not explained. It became UK patent 12,889 and languished in obscurity. Other oddities included Senior's grenade (105,400, filed in April 1916) which had knife edges to alter the flight path of the grenade when 'thrown in a particular manner'. It was intended to go round corners like a boomerang. Then there was Marks's grenade (136,857, filed in June 1917), a disc-shaped bomb constructed in two conical sections joined to form an object that resembled a discus. One section contained the explosive, the other section contained the bullets, the idea being that on detonation the bullets were sprayed out.

It was not clear how the grenade was supposed to align itself so that the bullets sprayed in the direction of the Germans rather than the British. It was hardly practical although Shaw Grenades Ltd who owned the patent seemed to think it was. Neither was accepted for service use.

It is possible that these were all inspired by the German *Diskusgranate* which was in service in 1915. It had four metal tubes leading to the centre, each of which contained a percussion cap. At the centre of the grenade was a star-shaped striker. A large tube at the top of the grenade contained a brass pellet which covered the striker until the grenade was thrown. A lower tube contained the detonator which was fired by whichever percussion cap was struck when the grenade landed. However, the German troops which used these were not altogether happy with them because of the ease with which they could be accidentally detonated, and treated them with suspicion.



One of the war's oddities, the discus grenade invented by E.C.R. Marks of Shaw Grenades Ltd. Half of the body contains bullets which, on impact, is supposed to rotate about the central spindle to release spring-activated rotating strikers (the top and bottom triangular pieces in the upper drawing) to hit the detonators as indicated by the dotted curves.



The Diskusgranate *in section, showing its mechanism. It contained two circular bags of explosive, each holding 2 oz. To use the grenade, it was held in the right hand with the safety pin upwards and the pin was pulled with the left. The cap was removed and the safety pellet was held in position with the right forefinger (if necessary the pin could be replaced). When throwing, it was important to ensure that it went as high as possible with the edge vertical. Each box of grenades included a wrist strap with which the grenade could be thrown and the fuse fired but this required a lot of practice. In flight, the grenade spun like a wheel, releasing the safety pellet, which flew out. On detonation, fragmentation was lateral. This grenade clearly inspired British inventors.* (The Training and Employment of Grenadiers)

Some patents represent milestones in the development of the hand grenade; the inventions were major advances and had a profound impact on grenade technology. The prime example of this was the Mills. Other patents represented significant refinements on existing patterns, usually the Mills, and often to its central section that housed the fuse, detonator and firing mechanism. Of all the grenade patents granted during the First World War, those granted to William Mills and to others who developed the grenade are the most important; nine were granted to Mills in 1915.

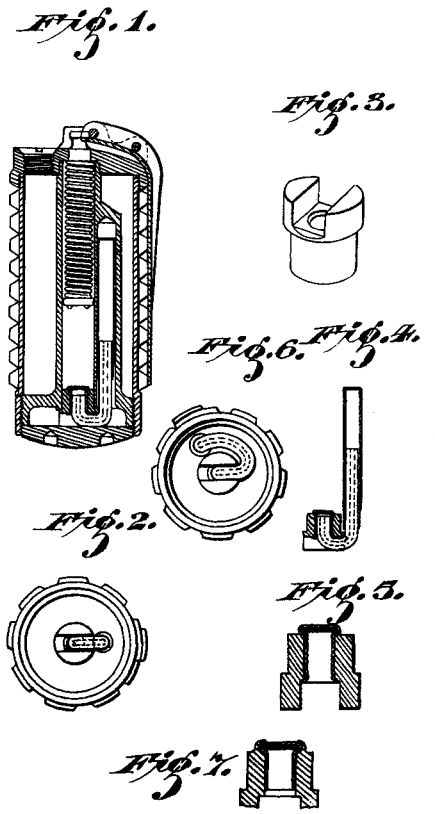
When the Mills appeared on the scene, the heavier types of grenade were dropped from departmental development programmes. This was mainly because their weight precluded soldiers from carrying many of them at a time and the high explosive charges they contained made them dangerous to friendly troops. The Mills was vastly superior to what had gone before and what was in development. Frank Richards was not alone in his opinion that the Mills was the best grenade of the war on either side. The Mills changed everything about British hand grenades for decades.

William Mills was born in 1856 and educated in Sunderland where his father was a shipbuilder. Eventually, almost inevitably, he was apprenticed as a marine engineer and went to sea. He was an accomplished engineer with a distinguished career behind him before the outbreak of war (he was fifty-eight in 1914) and well used to solving problems. He established the first aluminium foundry in Britain and was a pioneer of research into alloys of aluminium, an important material in the blossoming aircraft industry of the second decade of the twentieth century. By the end of the war, the consumption of aluminium in the aircraft industry was huge and his companies in Sunderland and Birmingham had produced an enormous quantity of aluminium castings for the leading manufacturers in the aircraft industry. Before the grenade that was to make him world famous and turn his name into a household word, he already possessed a number of patents in the fields of foundrywork and metal moulding.

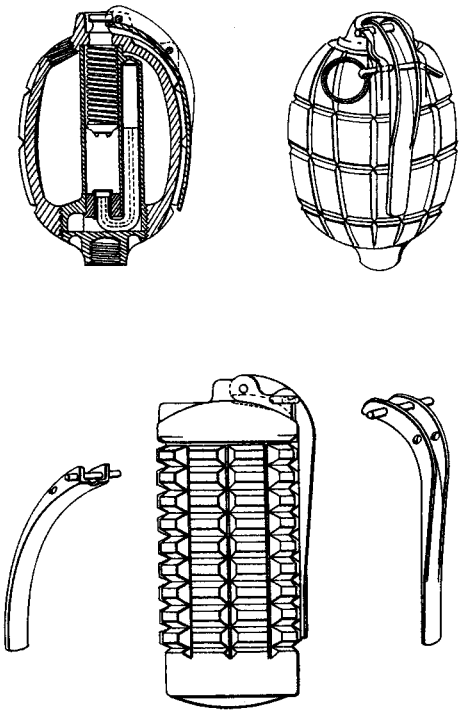
Mills had no experience of munitions, however, and that he came to invent a hand grenade was down to a chance meeting. A Belgian engineer called Albert Dewandre and his colleague Captain Leon Roland, an officer in the Belgian Army and working for Compagnie Belge des Munitions Militaires, had devised a grenade which contained an automatic fuse ignition and detonation system which overcame the problems of accidents associated with impact fuses and the ingress of moisture common with safety fuse grenades. The grenade did away with the need to use a cigarette or portfire to light a length of safety fuse. In short, it was a breakthrough in grenade design. The problem was that it was far from perfect and Captain Roland was no longer available to develop the device because he had become a prisoner of the Germans in 1914. There were serious flaws in the design that needed to be resolved before the grenade could be manufactured and used with confidence. Fortunately, Dewandre happened to meet William Mills in 1914 and they talked about the grenade.

Mills was very much taken with it and believed that between them they could come up with a design that worked and which could be manufactured without a lot of complex machining. In the end, Mills so altered the original Belgian idea that there was a gulf of difference between them, and what Mills produced can be fairly said to be his and not merely someone else's idea slightly modified. Mills turned a good idea into something that worked.

Mills and Dewandre took the grenade to the Inventions Branch of the Directorate of Artillery, yet another inventions investigation department, in late January 1915. The Inventions Branch expressed considerable interest in it and gave the go ahead for immediate trials. At this first meeting, Mills must have told them that he was about to file patent applications in respect of the grenade because on 10 February he filed two, one for the fuse assembly, the other for the lever and striker mechanism. These applications were subsequently



Drawings from Mills's first grenade patent, 2,111/15, showing the arrangement of the fuse, striker and lever. Fig. 3 is a perspective view of the cap holder, while figs 5 and 7 show holders with caps in place. Fig. 4 shows the cap and fuse assembly as it 'may be . . . introduced into . . . the grenade'.



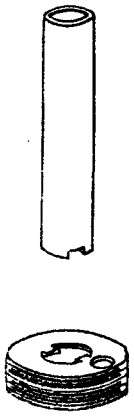
Drawings from Mills's second grenade patent, 7,636/15, with the familiar Mills shape. The base plug has a screw thread for a rod to enable the grenade to be fired from a rifle. The design of the centre-piece is clear from the top left-hand drawing. Note the design of the lever head. This patent mentions a grenade cup attached to the rifle to retain the lever.

granted as 2,111/15 and 7,636/15 respectively, both within eight months of the application date. He filed another application six days after the first two. This, when combined with yet another filed shortly after that, became UK patent 2,468/15 and related to the venting of gases from the percussion cap as it detonated. It was also concerned with preventing the fuse from being pushed home incorrectly to ensure that there was a space between the fuse and the cap. This represented a strong portfolio of patents for the grenade and more were to come.

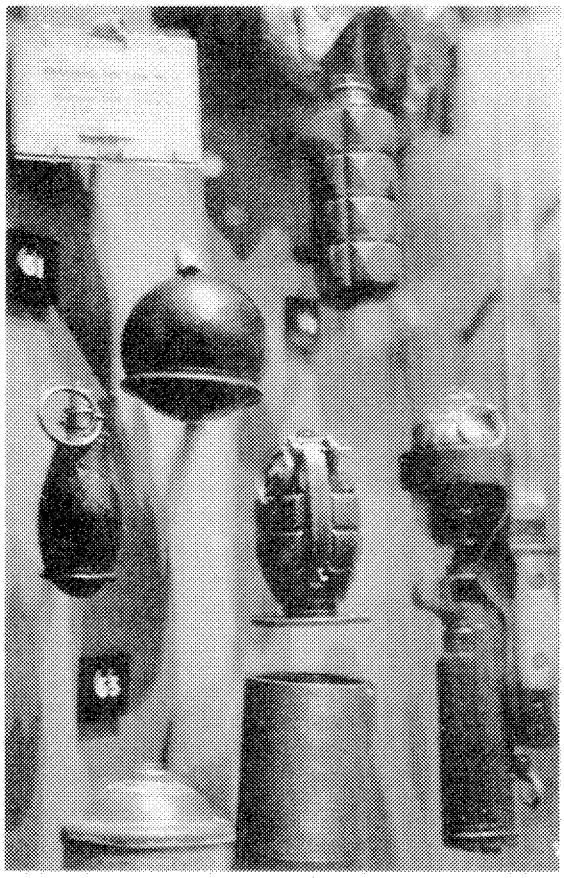
The Mills grenade was first issued as the No. 5 Mk I in the late spring of 1915, but it was still considered to be new a year later because some battalions had hardly seen it in all that time. In appearance, all subsequent versions of the Mills remained essentially unchanged. The barrel-shaped casing was made of cast iron and segmented to aid fragmentation. The explosive filling hole was near the top, closed by a brass screw which was carefully cemented in place after filling. Fixed centrally inside the casing was an aluminium centre-piece. This was a fairly complicated structure but fundamental to the grenade. It consisted of three parts: an open-

ended tube; next to it another smaller-bore tube, one end of which was closed and the other open; and a base which took the two tubes and screwed into the bottom of the grenade. A base plug was screwed in after it. At the bottom of the open-ended tube was a rimfire percussion cap that sat in a holder, into which fitted the end of a 5-second fuse which curved away under the main tube and into its smaller neighbour which contained the detonator (the No. 6). The fuse resembled a letter J, the shorter part being under the cap.

The centre-piece was often made as one part although it was also made in three sections which were then soldered together. In September 1916 G.C. Salsbury filed an application for a patent concerned with the centre-piece in which the main tube had slots which engaged with lugs in the base before being soldered to it to make a firmer join that would 'take up torsional and longitudinal stresses'. This may have been directly related to the forces on the grenade when it was discharged from a rifle. Several other similar patents concerned with the centre piece were granted in respect of the method of manufacturing it, all of them designed to make production easier (e.g. C.W. Findlay, 17,397/15, filed 11 December 1915; S.R. Parkes, 17,898/15, filed 22 December 1915; J. Walker, 102,173, filed 21 January 1916; Oritur Manufacturing Co. and J.W.G. Starkey, 106,555, filed 8 July 1916; A.B. Gibbons, 114,122, filed 20 November 1917). The bottom of the centre-piece made a 'firm base to receive the shock of the striker when released'.



The centre-piece of the Mills designed by Salsbury (UK patent 102,364). The detonator holder is not shown. The notches in the cylinder engage the lugs in the base which has an external screw thread.



Grenades on display in the Imperial War Museum. At the top is a Pitcher, below that is a Ball, below which, on the left, is a British egg grenade. Next to that is a Mills fitted with a gas check disc for firing from the Burn cup discharger that is beneath it. On the right is the first pattern cup attachment for firing the rodded Mills, shown with the bayonet attached. The dome at the foot of the photograph is the top of a British anti-tank grenade.

The spring-operated striker, which when released exerted an impact force of 30 lb, was secured at the top of the main tube by a lever. The top of the striker was narrowed and topped by a flange and the end of the curved lever fitted into the narrowed part and under the flange. The top of the lever had a pair of short trunnions to act as a pivot which sat in grooves in parallel projections on the top of the casing and either side of the lever. The lever was held in place by a safety pin that went through holes in the projections and through the lever, holding it against the casing. So long as the pin retained the lever against the casing, the striker remained where it was above the cap and the grenade was safe but once the pin was removed and the lever released, the striker would hit the cap which would ignite the fuse. The thrower then had 5 seconds to get rid of it, preferably in the direction of the enemy. As long as the thrower gripped the whole grenade, pressing the lever against the casing, the pin could be removed without danger – in theory, at least. This was the first grenade to use this method of a spring-operated striker and lever. It was the first service grenade anywhere to have an effective automatic ignition system. The match and the glowing cigarette end were redundant.

The two Mills patents give some idea of how the original Roland grenade worked. In 2,111/15, the complete specification explained that

> In grenades of this type heretofore proposed, the arrangement is such that the proper assemblage of the time fuse is a matter of considerable difficulty. The separable part . . . which carries the percussion cap is first screwed into the grenade. Then the time fuse has to be assembled and in this operation the end of the time fuse has to be inserted into the already assembled separable part. The relationship between the percussion cap and the time fuse is a vital matter in the working of the grenade and with improper assemblage the firing of the time fuse by the percussion cap is liable to fail.

It then goes on to explain what the invention is.

> According to the present invention the separable part in relation to which the percussion cap and time fuse are assembled is adapted to be assembled in the grenade without being screwed therein; thus the percussion cap and time fuse can separately from the grenade be combined with said separable part in a unit and disposed in the form and arrangement which they assume when in the grenade and be afterwards so assembled in relation to the grenade as to render it unnecessary in such assemblage to alter or disturb the form and arrangement of the parts of which the unit is composed. The unit can be transported separately from the grenade and can, when the latter is ready for use, be assembled with extreme simplicity and accuracy.

Perhaps it should be pointed out that the 'statement of invention' of a patent must consist of a single sentence, no matter how unwieldy it becomes.

The second patent, 7,636/15, dealt with the lever. Again, it provides an insight into the original Roland grenade.

> In grenades of this type heretofore proposed the external lever has been adapted to rock on the edge of the opening of the grenade body from which the striker projects; this arrangement I have found unsatisfactory in action and the lever is liable to fail to release the striker. My present invention has for its purpose to provide for a free and particularly effective and certain operation of the lever and with this object in view the

> external member is mounted with a pivot advantageously constituted by trunnions adapted to work in bearings provided upon or in connection with the body of the grenade.

The complete specification went on to explain that

> during the operation of releasing the lever . . . [it] can be grasped by the hand, whereby in this grasping operation the greatest possible leverage is obtained which reduces the possibility of the lever being accidentally released by the hand.

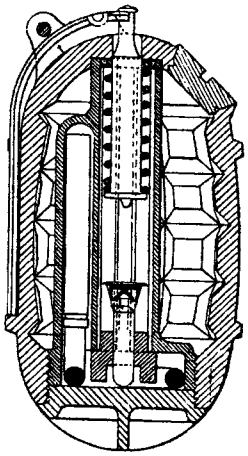
Almost as soon as the No. 5 Mills was adopted as a service grenade there were problems. Difficulties experienced with its manufacture kept the numbers low until the middle of the summer of 1915. The Trench Warfare Department took over responsibility for the contracts at the beginning of July when only 16,000 had been delivered; the War Office had ordered 5,000,000. By mid-August, on the instructions of the Trench Warfare Department, orders had been nearly doubled but production was still proceeding at a snail's pace and by 4 September deliveries from the contractors amounted to less than 10 per cent of the quantity ordered. In an effort to increase the rate of supply, the department arranged for a number of explosive filling stations to be set up in different parts of the country as well as making 'very extensive arrangements for inspection, assembling, packing and despatch'. It was partly because of these production difficulties that improved ways of making the centre-piece were devised as its manufacture was one of the main causes of the delays. By October output had exceeded the '120,000 per week, asked for by the Field Marshal'. In fact, it was now in excess of 300,000 a week and was soon to reach 400,000 a week.

More than twenty contractors were involved, including the company already owned by Mills, William Mills Ltd, and a new one set up for the sole purpose of manufacturing the grenade, Mills Munitions Ltd, both of which were in Birmingham. Each unfilled grenade cost 3–5*s*; filled ones were costed at between 5*s* 3*d* and 6*s* 9½*d* (about 26–34p). Among the other contractors were Vickery's Patents Ltd and Dover Ltd, both of which developed new types of lever. In late 1917 Dover filed a patent application (which became 117,734), while Vickery's seems to have been set up specifically to make munitions. It is unlikely that Vickery's was a patentee but obtained licences to use other people's patents – hence the name – although Vickery's certainly made some significant contribution to the lever which in 1921 led to a claim being submitted to the Royal Commission on Awards to Inventors in respect of the improvement in safety which it conferred on the Mills.

The production difficulties were not helped by the need to change the cap due to a rash of accidents. And blinds were rather too common. In June 1916 the Royal Welch Fusiliers amused themselves by 'lobbing blinds . . . a good average throw was 20 yards'. There were several causes of accidents according to Major Beddoes when he gave evidence as an expert witness at a hearing for the Royal Commission on Awards to Inventors in January 1921 in respect of the claim made by Vickery. Among them were faulty fuses due to their being poorly made, prematures caused by soldiers interfering with the fuse, and poor design of the top of the striker and the way the lever engaged it. In addition, prematures were caused by inadequate venting of the gases from the detonated cap which adversely affected the fuse. Then there were problems with the head of the striker which had two raised points on it to detonate the cap; sometimes the points failed to hit the rim of the cap properly so that the cap failed to detonate. The number of accidents was running at one for every 3,000 grenades, which was far too high.

The problem with the striker and lever arrangement was a serious defect as it went to the very heart of the grenade and the way it worked. It was found quite early on that if the bomber relaxed his grip on the lever while holding the grenade, even only slightly – something that was very easy to do without realizing it – the striker was released, even though the lever was still held firmly against the casing of the grenade. The lever movement was supposed to have an allowance of 1.25 in before the striker was released but sometimes a very much shorter movement released it. This was a common occurrence in the early days of the grenade and Beddoes gave evidence that there were hundreds of accidents due to this happening. With a similar root cause, accidents also happened when the grenades were carried in the canvas buckets or bags used to bring the grenades to the Front from the supply dumps. The lever of one would catch the pin of another and pull it out because of the jolting and bouncing around of the grenades inside the bucket. This kind of thing was common knowledge. With the Mills it was essential to make sure that the ends of the pins were properly split (grenade pins were always malleable split pins) and bent back to prevent them being accidentally pulled out. They were kept like this until they were needed and then someone had the onerous task of straightening them again, usually on the fire-step of the front-line trench.

Dewandre, meanwhile, continued along a different line of development derived from the original Roland grenade and, with J. de Laminne as co-patentee, filed four patent applications in Britain on 15 June 1916 for his new grenade, which used a weak percussion cap in a holder made of an elastic material (UK patents 141,743 and 141,744) which may have been a plastics or rubber compound (which would make this one of the earliest uses of plastics in ammunition). The weak cap was presumably intended to overcome the problems associated with poor venting of the cap gases in the Mills. Internally, it resembled the Mills but was more complex and included a ribbed main tube to help guide the striker and help the venting of gases (UK patent 141,741). The second of the four, UK patent 141,742, was concerned with a lever made of an elastic material which by virtue of being bent round the casing exerted an outward force against the safety pin helping to keep in it firmly in place and preventing accidental removal. Again, 'elastic' suggests that the lever was intended to be made of a plastics material, an innovative departure from the metal lever of the Mills. A plastics material would certainly have been tough enough and resilient enough for the job. Plastics did not become a common material in grenade construction until the 1970s, however, although the British No. 69 of the Second World War was almost entirely made of a phenolic plastic (Bakelite) and the No. 74 Sticky Bomb also made use of phenolic components.

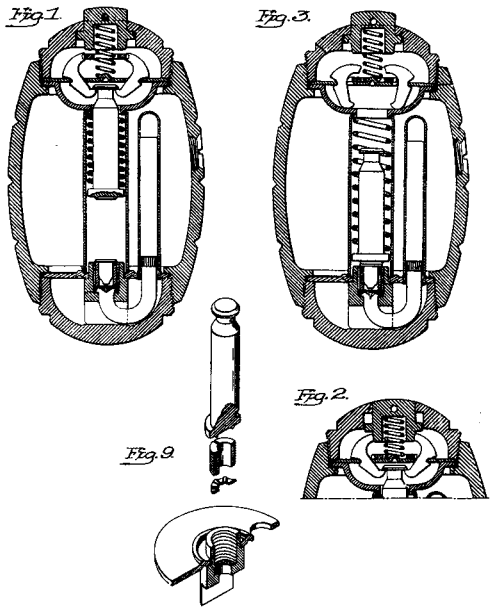


Dewandre's development of the original Belgian grenade that inspired the Mills. The similarities with the Mills are outweighed by the many differences. The detonator is on the left. The fuse descends to the base plug and runs round to the opening of the central tube. The black circles are sections through the fuse cord and the short, central, parallel-sided oval is the fuse as it passes through the holder to the percussion cap.

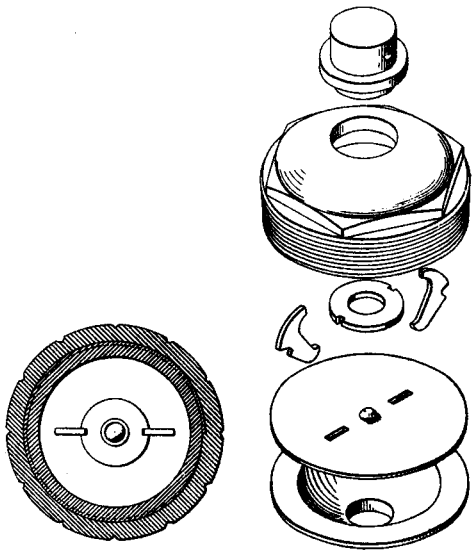
To begin with, there were great difficulties in training bombers with the No. 5, the 'ordinary Mills', because of the problems with the lever. Beddoes also pointed out that no one was ever taught to release the lever and count to three before throwing the grenade, which only had a 5-second fuse. However, that did not stop this from happening. Charles Carrington cited an example of this when a Mills exploded in the face of a German before it hit the ground which he put down to the thrower, a Lance-Corporal Matthews who 'knew nothing of the technique of bombing', having held the grenade after releasing the lever, before throwing it. This was not a safe thing to do. The 'ordinary Mills' did not have a good reputation.

Clearly, these problems had to be addressed as soon as possible. Mills devoted much time and effort to their resolution. He was aided by William Morgan, a professor of automotive engineering at Bristol University and later by F.J. Gibbons a manufacturer of locks, altogether an odd collection of people to solve munitions problems, but solve them they did, along with Vickery. Whereas Vickery never obtained a patent, Mills and Morgan as co-patentees obtained two fuse patents related to the Mills (10,925/15 and 14,665/15), while Gibbons successfully applied for two, one related to the fuse, the other to the lever and striker (110,068 and 111,949).

The No. 23 Mk II version of the Mills, introduced in 1916, incorporated some of the solutions to these problems as embodied in 10,925/15 and 14,665/15. To some extent, better training in the newly established bombing schools helped to prevent some of the accidents. The problem with premature release of the striker was largely overcome by teaching bombers



Drawings from one of two patents granted to American Harry Asbury in March 1917 (filed in March 1916). These are from 104,542 and illustrate a different kind of mechanism. The striker is held above the percussion cap by latches. These are disengaged by pressing and releasing the button. This is demonstrated by figs 1–3. Such a design would have made it awkward to hold the grenade.



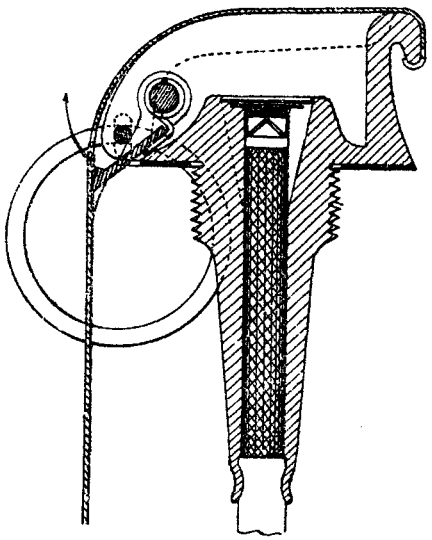
Drawings from the same Asbury patent illustrating the button and latch system. The spring is not shown. The striker fits through the hole in the lower dished plate. The latches fit through the slots in the disc.

to grip the grenade with the lever against the palm of the hand rather than by pressing it against the grenade with the fingers. However, irrespective of how much better training had become, this did not deal with the basic problem of the striker being released too readily and before the bomber chose to release it. Nevertheless, the No. 23 Mk II was more reliable than the No. 5. The striker head in the No. 23 Mk II was redesigned with a diagonal slot cut into it (when viewed from the side) which extended right through it and along the side of the striker body for about ⅛ in. This adequately vented the cap gases and prevented premature ignition of the detonator. The twin points of the striker head were discarded and replaced by a sharp ridge that ran round the perimeter of its face. This prevented misfires by ensuring that the rim of the percussion cap was always struck squarely.

Mid-1917 saw a complete redesign of the Mills grenade, including improvements to the firing mechanism, and it eventually emerged as the No. 23 Mk III and the No. 36 which were essentially the same thing. The most important change was to the head of the striker and the lever. The striker was no longer narrowed and flanged at the top but of equal diameter all along its length, with a deep slot cut into the top to engage the new lever. With this system it was practically impossible for the bomber to inadvertently release the lever and therefore accidents of that sort stopped. Moreover, there were far fewer bucket-type accidents. The Munitions Invention Department trialled a new lever with 'an improved method of pivoting and weighting' in mid-1918, designed to prevent accidental detonation when a Mills was dropped after the pin was removed. It is not clear whether this was the Gibbons/Vickery lever. Because the Mills was now much safer and more reliable, bombers had greater confidence in it. However, it seems that Mills himself was not in favour of some these changes to the striker and lever and told Newton in the Trench Warfare Department that they were unnecessary. Clearly, he was overruled.

Generally, opinion of the Mills was high. The front-line soldier had come to expect grenades to be more dangerous to their own side than to the enemy, a somewhat pessimistic view based on experience, largely due to the high number of accidents with early grenades. Because the Mills came to be the epitome of reliability and safety, its early dangers were often overlooked by memoirists after the war. But not everyone was enamoured of it. For some, the Mills at 3.75 inches in length and 2.3 inches in diameter was too big to get a good grip, while at between 1 lb 7 oz (No. 5) and 1 lb 9 oz (Nos 23 and 36) it was too heavy to throw as far as the German potato-masher (Frank Richards likened it to a 'swede-smasher'). This was a genuine concern (although Brothers was of the opinion that on the whole the British bombers could always out-throw German bombers) and when the Germans introduced the light egg grenade which could be thrown much further than the heavier Mills it became a real headache.

According to Richards, a Mills could be thrown between 20 and 30 yd although some could throw them even further, but he admitted that many could not throw them even 20 yd. On the other hand, Carrington thought that 30–40 yd was possible if 'bowled like a cricket ball with a full pitch'. The Mills, and indeed all hand grenades, was a short-range weapon and the troops were not encouraged to rely on them to stop an attack, although this tended to happen. Richards was not alone in his opinion that 'Mills bombs were wonderful for throwing into shell holes, trenches and dug-outs, but were absolutely useless for holding up attacks'. In 1917 Haig sent out a notice about not relying on the grenade to stop attacks but to make full use of the rifle, quoting the examples of Le Cateau and First Ypres in which German assaults had been halted by rifle fire alone. Excessive reliance on the grenade was blamed for losses of ground during German counter-attacks. What he failed to mention was that there were not only no hand grenades then but that the regulars who fought those battles



*A French lever and rotating striker 'mousetrap' mechanism. Leblanc filed his application in August 1916 which was granted as UK patent 127,293. The dotted line represents one of two side walls through which passes the spindle of the striker. The whole unit screws into the body of the grenade. This was used on the French OF (*offensive-fusante*) grenade.*

were well trained in pre-war musketry and were highly skilled at aimed rapid fire which the new arrivals in 1917 certainly were not. According to Richards, new recruits hardly knew how to load a rifle.

But in trench work the bomb was king – provided the bomber remembered to pull the pin first. Charles Carrington related an incident on the Somme when a bomber forgot to remove it before throwing. It was immediately returned by a German, this time without the pin. Sassoon described a bombing attack along a German trench in 1917 in which he commanded a section of twenty-five men that included fifteen bombers each armed with ten Mills, four men armed with rifle grenade dischargers each with five grenades, five grenade carriers who acted as bayonet men, and a sergeant. His objective was to clear 500 yd of trench. Alone, he came upon a Cameronian corporal with a bag of grenades in the trench, a survivor of an earlier attack. Together they advanced, throwing bombs as they went without a word passing between them. The corporal 'who was obviously much more artful and efficient than I was . . . dodged up the saps at the side' each time he threw a Mills. They reached their objective without seeing a German, only retaliatory bombs.

Charles Carrington described bombing as 'a scurry . . . in which parties of men rushed up and down the trenches throwing bombs at one another, a most unsatisfactory employment, exceedingly unpleasant and rarely leading to decisive victory for either party'. He explained that the reason that grenades had to be used in trenches was because of the 'tortuous plan on which trenches were always dug'. Straight trenches could be enfiladed so bays were separated by traverses every 5–10 yd in a castellated pattern. It was 'like walking in a maze', there were so many corners which made it difficult to maintain a sense of direction. To move along a trench was very tiring 'squeezing past people at narrow bends, paddling through mud and water, climbing over obstructions made by shell-fire and being caught under the chin or across the ankles by trailing telephone wires', all made worse when it had to be done at night.

When a position had been fought over, the difficulties were magnified by the debris and destruction. The trenches of the Somme battlefield 'became a labyrinth', weaving in all directions in a chaotic web, with bomb-stops erected at intervals to separate friend from foe and prevent the enemy from bombing his way along them. Under such circumstances, it was hardly surprising that the bomb and the Mills in particular came to such prominence. The stress of bombing along trenches was enormous. Grenades could have a deeply psychological effect. The Germans called this *Granatfieber*, grenade fever, a form of war neurosis.